Core 1

State one safety reason why

(a) radioactive sources should not be touched with bare hands,

.... [1]

(b) radioactive sources emitting γ-rays should be stored in lead boxes with thick sides,

.... [1]

(c) the radiation symbol should be displayed on the cupboard or drawer in which radioactive materials are kept.

.... [1]

Core 2

(a) One nuclide is written as $^{210}_{84}Po$.

(i) Which figure is the proton number (atomic number)? ....

(ii) Which figure is the nucleon number (mass number)? ....

(iii) Which figure gives the number of protons in the nucleus? ....

(iv) How can you find the number of neutrons in the nucleus?

....

[4]

(b) An α-particle can be written as $^{4}_{2}\alpha$.

Polonium $^{210}_{84}Po$ decays into lead (Pb) by emitting an α-particle.

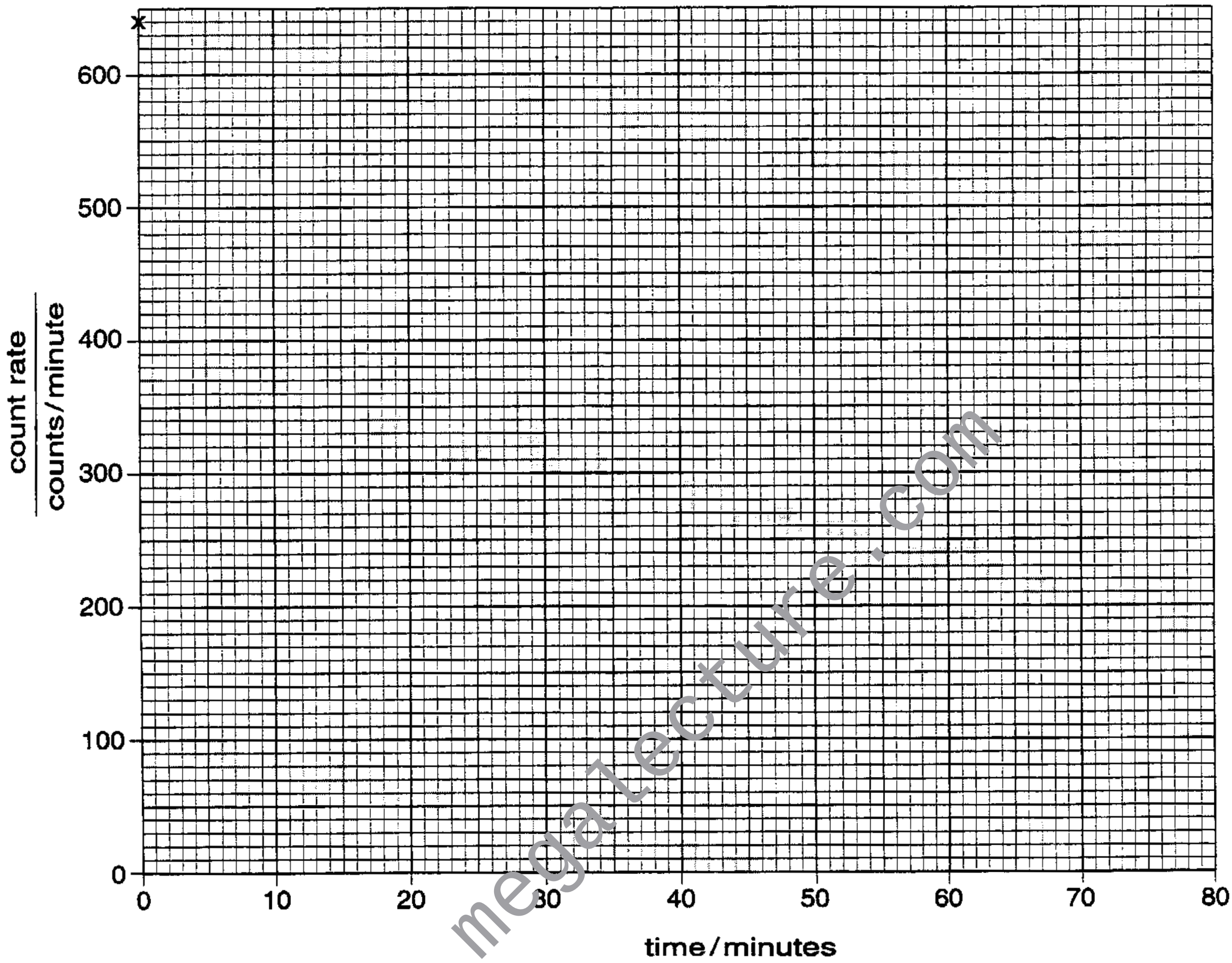
Complete the nuclear equation below, by writing the correct numbers in the boxes.

$$^{210}_{84}Po \longrightarrow {}^{\square}_{\square}Pb + {}^{4}_{2}\alpha$$

[2]

Core 3

This question deals with the decay of a radioactive source.
The radioactive source has a count rate of 640 counts/minute at the start of an experiment.
This value has been plotted on Fig. Fig. 1



Fi Fig. 1

The source has a half-life of 20 minutes.

(a) **(i)** What would you expect the count rate to be after 20 minutes?

.... counts/minute

(ii) Plot this value on the graph. [2]

(b) **(i)** What would you expect the count rate to be after a further 20 minutes (i.e. 40 minutes after the start of the experiment)?

.... counts/minute

(ii) Plot this value on the graph. [2]

(c) Plot two further points which might be expected if the decay curve were perfect. [1]

(d) Draw a smooth curve through all five points on your graph. [1]

(e) If this perfect decay continued, how long would it take from the beginning of the experiment for the count rate to decrease to zero?

Tick **one** answer.

90 minutes ☐

100 minutes ☐

120 minutes ☐

a very long time ☐

an infinite time ☐ [1]

(f) In a real experiment, the values found for the count rates might not all lie exactly on a smooth curve. One reason for this might be experimental error. State one other reason.

....[1]

Extension 1

(a) A radioactive source contains an isotope of thorium.
Thorium ($^{228}_{90}Th$) decays by α-particle emission to radium (Ra).
Write an equation to show this decay.

[2]

(b) The radium produced is also radioactive. Fig. 2 shows a laboratory experiment to test for the presence of the radioactive emissions from the thorium source, using a radiation detector.
In the laboratory there is a background count of 20 counts/minute.

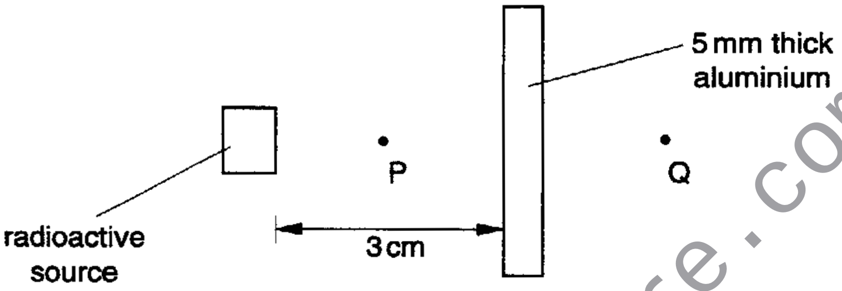


Fig. 2

The readings are given in the table.

position	reading in counts/minute
P	2372
Q	361

State and explain

(i) which radiation could be causing the count at Q,

....

....

....

(ii) which radiations could be causing the count at P.

....

....

....

[4]

Extension 1

(c) All three types of radioactive emission cause some ionisation of gases.

(i) Explain what is meant by the term *ionisation of gases*.

....

....

....

(ii) Suggest a reason why g-r γ liation produces very little ionisation.

....

....

....

[3]

Extension 2

(a) A nuclide, symbol $^{A}_{Z}X$, decays by β-particle emission to a nuclide, symbol Y. A β-particle has the symbol $^{0}_{-1}e$.

Write an equation for this decay.

[2]

(b) Fig. 3 shows how a β-particle source may be used to measure the thickness of paper as it is being produced.

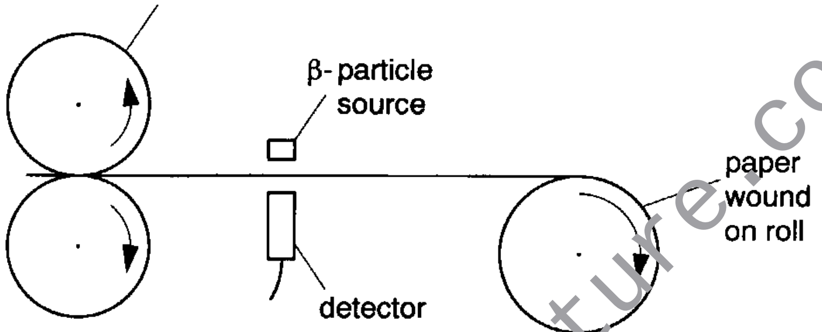


Fig.3

(i) Explain why the reading of the detector changes with the thickness of the paper.

....

....

....

(ii) Write down two reasons why β-particles are more useful than γ-rays for this purpose.

reason 1. ....

....

....

reason 2. ....

....

....[4]

Extension 2

(c) Fig4 shows a beam of β-particles entering a magnetic field, the direction of which is into the paper.

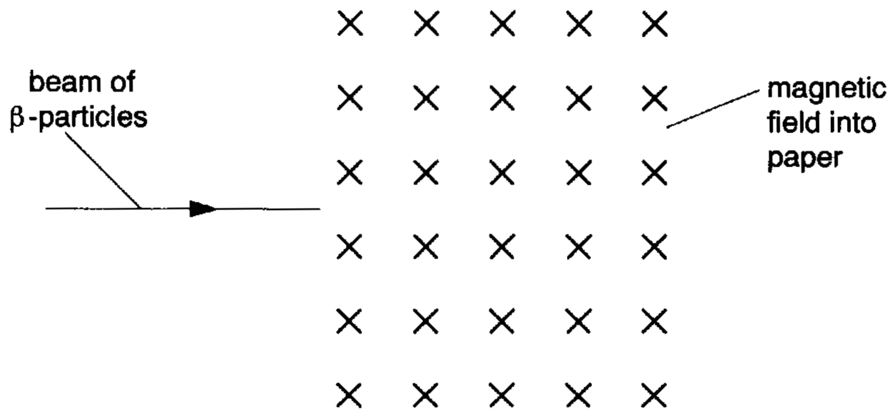


Fig4

On Fig4 continue the path of the beam of β-particles as they pass through the magnetic field. [2]

Extension 3

Lengths of steel may be joined by welding them together, as iillustrated in Fig 5

Fig. 5.

A liquid radioactive source is to be used to test that the welds joining lengths of steel pipe are of equal thickness.

The diameter of the pipes is 120 mm and the pipe wall thickness is 5 mm.

The liquid runs through the pipes whilst a suitable detector moves around the outside of the joints.

(a) With the aid of a labelled diagram, explain how this method detects places where the welds are thinner than 5 mm.

....

....

....

....[3]

Extension 3

(b) In order to find out the most suitable type of isotope for this purpose, tests were carried out on the ability of the radiations from an α-emitter, a β-emitter and a γ-emitter to penetrate steel.

(i) Write down what you would expect to be the results of these tests.

α-emitter ....

....

β-emitter ....

....

γ-emitter ....

....

(ii) State and explain which type of emitter would be most useful for testing these welds.

....

....

.... [4]

(c) Describe three precautions which should be taken to ensure the safety of the operator who is making these tests.

1. ....

....

2. ....

....

3. ....

....[3]

Core 1

a to avoid contamination

b to prevent radiation getting out

c to warn of the presence of radioactive material

Core 2

a(i) 84 or bottom one

(ii) 210 or top one

(iii) 84 or bottom one

(iv) 210 – 84 or take bottom from top or take proton number from nucleon number

b 206
82

Core 3

a(i) 320

(ii) plot must be to within +/- ½ small square

b(i) 160

(iii) plot must be to within +/- ½ small square

c points plotted at (60, 80) and (80, 40) +/- ½ small square

d smooth curve through points by eye

e either of last two boxes ticked

f randomness or background

Extension 1

a $^{228}_{90}Th \longrightarrow {}^{4}_{2}He + {}^{224}_{88}Ra$

b(i) must be γ because α and β are absorbed by aluminium

(ii) α or β or γ

c(i) atoms of gas gain or lose electrons by colliding with particles

(ii) any three from

they are photons not particles
they have no mass
they have no charge
they do not have enough energy

Extension 2

a $^{A}_{Z}X \longrightarrow \, ^{0}_{-1}e + \, ^{A}_{Z+1}Y$

b(i) some beta absorbed by paper
thicker paper, less pass through / lower reading

(ii) no gamma would be absorbed by the paper
gamma are less safe

c diagram should show a smooth curve
towards the bottom of the page

Extension 3

a the diagram should show the radioactive liquid on pipe, weld and detector in correct places
where the weld is thin the reading rises
radiation passes more easily through / is less absorbed by thinner metal

b(i) alpha – none passes through steel
beta – some passes through steel
gamma – most / all passes through steel

(ii) either beta or gamma with a clear reason (alpha absorbed completely)

c general shielding / absorbing
distance
monitoring radiation received